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Indian Standard

TEST CODE FOR GRAIN DRYERS

PART 2 METHOD OF TESTS FOR CONTINUOUS DRYERS

UDC 631·365·22-932·2 : 620·1

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Indian Standard

TEST CODE FOR GRAIN DRYERS

PART 2 METHOD OF TESTS FOR CONTINUOUS DRYERS

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Indian Standard

TEST CODE FOR GRAIN DRYERS

PART 2 METHOD OF TESTS FOR CONTINUOUS DRYERS

0. FOREWORD

0.1 This Indian Standard (Part 2) was adopted by the Indian Standards Institution on 31 July 1984, after the draft finalized by the Agricultural Produce Processing Equipment Sectional Committee had been approved by the Agricultural and Food Products Division Council.

0.2 It is well known that if the crop having low moisture content is harvested, the shattering loss is more and if it is harvested at high moisture content, the storability and quality of the grain is very much reduced. In order to have a compromise between these two extreme situations, it is desirable to harvest the crop at a comparatively high moisture content and dry the grain to the required moisture content suitable for its storage and quality maintenance. Drying may be done in sun or by mechanical process. Sun drying is time consuming and a non-uniform process. Moreover in some grains such as paddy, the quality of the grain is reduced if it is dried in the sun. It is, therefore, advisable to employ mechanical dryers. This would ensure the increased manufacture and use of the grain dryers by processing industry in the country.

0.3 Although the function of the grain dryer is to remove excess moisture from grain without loss of quality, the evaluation of its performance is very complex due to a wide variety of designs and sizes to cover the diverse requirements for drying capacity and cost. This code is, therefore, being issued to provide a procedure for evaluating the performance of the dryers which should be of practical use to both the users and the manufacturers.

0.4 This standard is being issued in three parts. This part (Part 2) covers methods of tests for continuous dryers. Other parts of the standard are as under:

Part 1 Selection and preparation for test.

Part 3 Method of tests for insilo dryers.

0.5 In the preparation of this standard, assistance has been derived from the following:

BS 3986 : 1966 Methods of test for agricultural grain dryers. British Standards Institution.

ASAE S 248 : 2-1976 Construction and rating of equipment for drying farm crops. American Society of Agricultural Engineers.

0.6 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard (Part 2) prescribes the methods of testing of continuous grain and seed dryers to evaluate their performance.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 8420-1977† shall apply.

3. GENERAL

3.1 Continuous dryers are suitable for drying larger quantities of food grains or seeds and drying would be comparatively quicker and more even. They have a wide versatility of drying different kinds of food grains or oil bearing seeds in the same dryer by only changing the process parameters like drying air, temperatures, air flow rates, etc. Many types of continuous grain dryers are available in the market. The more important types are tower dryers with horizontal or vertical ducts, fluid bed dryers, etc.

4. PREPARATION OF TEST AND GENERAL TEST PROCEDURES

4.1 For the purpose of conducting the tests in the dryers, the general procedure laid down in IS : 8108 (Part 1)-1984‡ shall be followed.

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*Rules for rounding off numerical values (*revised*).

†Glossary of terms relating to grain dryers.

‡Test code for grain dryers: Part 1 Selection and preparation for test.

5. METHODOLOGY

5.1 The dryer shall be run at a manufacturer's recommended hot air temperature for wheat, paddy, maize or any oil bearing seeds, at 4 different discharge rates, so that different reductions in moisture content are obtained. The moisture content of the discharged grain shall be plotted against the discharge rates so that discharge rates corresponding to various required moisture reductions may be read off. An additional run shall be carried out at a higher temperature as a check on the margin of safety against damage to the grains or oil bearing seeds provided by the recommended method of operation.

6. ORDER OF TEST

6.1 The dryer shall be filled up with damp grain, prepared in accordance with the procedure laid down in Appendix B of IS : 8108 (Part 1)-1984* and subsequently started at the required hot air temperature with the discharge mechanism set to give an output rate corresponding approximately to a reduction of 6 percent in the moisture content of the grain or seed passing through the dryer. The moisture content of the output grain (as determined by a moisture meter) shall be continuously plotted on a time base and the setting of the discharge mechanism not changed after the graph being produced indicates that the grain or seed is being discharged at a substantially constant moisture content or after the mass of the grain discharged becomes equal to that of the holding capacity of the dryer, whichever is the longer period. The discharge mechanism shall then be readjusted and the process repeated. In all, 4 runs under steady conditions shall be taken, with different settings of the discharge mechanism over a range of output rates corresponding to reductions in moisture content from 6 percent to 3 percent. After completion of the 4 runs at the manufacturers recommended temperature, a further run shall be made at a temperature exceeding the recommended temperature by 15 percent of the amount by which recommended temperature exceeds 15°C. For this run the discharge rate shall correspond to a reduction in moisture content of approximately 5 percent at the recommended temperature. When this rate of discharge has been established, sampling of damp and dry grain would be continued as in the previous runs until steady conditions have been reached and maintained for at least 30 minutes.

7. CONTROL OF DRYING AIR CONDITIONS

7.1 The control of the drying air condition shall be by adjustment of the setting of an automatic control unit forming part of the dryer or by manual adjustment of the air heater, if automatic temperature control is not fitted. In those dryers where an automatic control is fitted, an auxiliary manual adjustment system should also be provided and this manual adjustment system could also be tested as agreed upon by the testing authority and the manufacturer. Adjustment for the purpose of maintaining a steady temperature of the drying air may be made at any time but any adjustment of the automatic control shall have the prior sanction of the testing authority.

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*Test code for grain dryers: Part 1 Selection and preparation for test.

8. MEASUREMENTS AND CALCULATION OF RESULTS

8.1 Whether the flow control mechanism of the dryer controls the rate of flow of grain into and out of the dryer, the measurement of flow shall be of the grain discharged from the machine. Measurement of grain flow shall be made by timing and discharge of a suitable mass of grain, collected during a number of complete cycles of the discharge mechanism. Details of suitable weighing apparatus and sampling method are given in Appendix A.

8.2 The hot air temperature shall be recorded continuously preferably on a recorder throughout the test and readings or records shall also be made continuously of the discharged grain temperature air intake wet and dry bulb temperatures and exhaust wet and dry bulb temperatures. Other temperatures shall be recorded if the testing authority considers those to be necessary for the purpose of a comprehensive test. Samples for determination of moisture shall be taken from the flow of grain entering and leaving the dryer at intervals of 10 minutes throughout the test, the rate of sampling for grain leaving the dryer being increased during the steady rate period so that a minimum of 12 output samples are taken during the test run. For the germination test, minimum of 10 input and output samples shall be taken during each test run.

8.3 Measurement shall be made of the power and fuel used during each test run. The measurement of drying shall be based on the mass of the grain discharged from the dryer in unit time, the mean moisture content of the discharged grain and the mean moisture content of grain of the same sample taken at the entry to the dryer. For this purpose, the mean moisture content shall be determined by the method specified in IS : 4333 (Part 2)-1967*. Methods on corrections of moisture content, fuel consumption rate and power consumption, etc, have been described in Appendix B.

9. PRESENTATION OF RESULTS

9.1 Results of the test shall be presented in the format given in Tables 1 and 2. Performance figures tabulated in Table 2 shall be derived from the adjustable data for output rate and fuel consumption shown in Table 1, by plotting these data on a base of corrected moisture content and reading off at relevant points.

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*Method of Analysis for foodgrains: Part 2 Moisture.

TABLE 1 SPECIMEN FOR CONTINUOUS FLOW DRYERS TEST CONDITIONS AND RESULTS

(*Clause* 9.1)

Sl No.	Characteristics	Run Number				
		1	2	3	4	5
i)	Ambient conditions:					
	Ambient temperature, °C					
	Ambient relative humidity, percent					
	Barometric pressure, kPa					
ii)	Grain:					
	Moisture content of wet grain (input), percent					
	Moisture content of dried grain (output), percent					
	Corrected moisture content dried grain*, percent					
	Output rate, t/h:					
	Germination of wet grain, percent					
	Germination of dried grain, percent					
	Depression of germination, percent					
	Output grain temperature, °C					
	Thickness of grain bed†, cm					
iii)	Dryer temperatures, fuel consumption and evaporation:					
	Hot air temperature, °C					
	Cooling fan inlet temperature, °C					
	Exhaust air temperature, °C					
	Exhaust air relative humidity, percent					
	Fuel consumption, 1/h‡					
	Power consumption, kW					
	Evaporation rate, kg/h					
iv)	Results adjusted to specified ambient conditions:					
	Fuel consumption, 1/h					
	Power consumption, kW					
	Evaporation rate, kg/h					
	Output rate, t/h					
	Specific evaporation, kg/1 of fuel					
	Specific energy consumption kj/kg§					

*Corrected moisture content corresponding to wet grain at 21 percent moisture content (*see* Appendix B).

†Where thickness is variable.

‡Or units appropriate to the fuel used.

§Heat equivalent of the corrected fuel and power consumptions have to be taken into account.

TABLE 2 TEST DATA

INPUT MOISTURE CONTENT PERCENT	OUTPUT MOISTURE CONTENT PERCENT	INPUT RATE t/h	OUTPUT RATE t/h	ENERGY REQUIRED PER TONNE OF DRIED GRAIN		
				For Air Heating Gas Oil, l	For Power kWh	Heat Equivalent of Total, kJ
21	17					
21	16					
21	15					
21	14					

9.2 The following information shall be given:

a) A list of repairs and modifications to the dryer made during the test;

b) Any comments on a particular feature of the dryer or its behaviour which might adversely or otherwise affect its practical performance, its safety in operation or the working conditions of the operator with particular regard to noise and dust. A comment on the evenness of drying shall also be included;

c) Information on points of practical importance obtained from the use of similar dryers shall be included in the report where appropriate;

d) A note on any features of the dryer installation which might have had an effect on the dryers performance;

e) The date of the test and the location of the site at which it was carried out; and

f) The published report may also include a foot note giving the manufacturer's comments on points raised in the report. The wording of such comments shall be agreed between the manufacturer and the testing authority.

APPENDIX A

(*Clause* 8.1)

MEASUREMENT OF GRAIN FLOW AND/OR MASS

A-1. The output grain flow shall be determined by measuring the mass of the grain discharged during consecutive intervals of time, each of not more than 5 minutes duration. Suitable types of weighing machines are:

a) An automatic or semi-automatic type in which batches are weighed continuously. The time of each weighing duration shall be recorded throughout the test unless the machine records the rate of flow automatically.

b) Platform type on which the grain is weighed in sacks. The time of filling of each sack shall be recorded throughout the test.

A-2. When very high rates of flow are encountered, the total flow may be divided and subsequently a known fraction weighed. The total flow shall be calculated from the weighed fraction. The flow dividing mechanism shall be positive in action and shall not change its calibration with varying conditions of the grain. A suitable type of flow divider is one in which the total flow is fed into a cylinder, divided into a number of equal segments, rotating at a constant speed on its vertical axis. The mass of grain passing through one of the segments is measured. The permissible weighing error shall be ± 1 percent of the net mass of the grain.

APPENDIX B

(*Clause* 8.3)

CORRECTIONS

B-1. CORRECTION TO MOISTURE CONTENT OF DRIED GRAIN

$$q_c = 21 - \frac{79\ (p_t - q_t)}{(100 - p_t)}$$

where

q_c = corrected moisture content of dried grain corresponding to wet grain at 21 percent moisture content;

p_t = mean moisture content of wet grain on test, percent; and

q_t = actual mean moisture content of dried grain on test, percent.

NOTE — This correction is made on the basis that for the small amount of the correction from $p_t = 21 \pm 1$ percent to 21 percent, evaporation rate is substantially constant, no account is taken of any change in evaporation rate associated with the change in moisture contents.

B-2. FUEL CONSUMPTION RATE

$$F_c = F_t \times \frac{T_{th} - 25}{T_{th} - T_{ta}} \times \frac{D_c}{D_t}$$

where

F_c = corrected fuel consumption rate in consistent units appropriate to the fuel used*;

F_t = fuel consumption rate on test;

T_{th} = mean hot air temperature on test, °C;

T_{ta} = mean ambient temperature on test, °C;

D_t = density of air at main fan on test, kg/m^3; and

D_c = density of air at main fan corresponding to specified ambient conditions, kg/m^3.

B-3. POWER CONSUMPTION

$$P_c = P_t \times \frac{D_c}{D_t}$$

where

P_c = corrected power consumption, kW; and

P_t = power consumption on test, kW.

B-4. EVAPORATION RATE

Method A (to be used when run mean exhaust relative humidity is more than 80 percent)†

$$E_c = E_t \times \frac{g_{ce} - g_{ca}}{g_{te} - g_{ta}} \times \frac{D_c}{D_t}$$

where

E_c = evaporation rate at specified conditions, kg/h;

E_t = evaporation rate on test, kg/h;

---

*For electrical heating, kW; for soild or liquid fuels, kg/h. Consumption on test and corrected consumption of liquid fuels are to be shown in Table 1 as l/h but should be converted to mass flow for this calculation to compensate for the effect of variation of density with fuel temperature.

†When run mean exhaust relative humidity is between 70 percent and 80 percent corrections should be made using the procedures of both Method A and Method B, and the average of the two corrected results inserted in Table 1.

g_{ta} = ambient absolute humidity during test, kg/kg of dry air;

g_{te} = exhaust absolute humidity during test, kg/kg of dry air;

g_{ce} = exhaust absolute humidity at specified conditions, kg/kg dry air;

g_{ca} = ambient absolute humidity at specified conditions, kg/kg dry air; and

g_{ce} = obtained from hydrometric tables to correspond with R_{ce} and H_{ce};

where

$R_{ce} = R_{te}$ = exhaust relative humidity percent (from Table 1) [*see* also **D-3.1** of IS : 8108 (Part 1)-1984*]

$$\text{and } H_{ce} = H_{ca} + \left[\frac{F_c}{F_t} \times \frac{D_t}{D_c} \times (H_{te} - H_{ta}) \right]$$

where

H_{ce} = exhaust total heat at specified conditions, kj/kg;

H_{te} = exhaust total heat during test, kj/kg;

H_{ta} = ambient total heat during test, kj/kg; and

H_{ca} = ambient total heat at specified conditions, kj/kg.

Method B (to be used when run mean exhaust relative humidity is less than 70 percent)†.

$$E_c = E_t \left[\frac{D_c}{D_t} \right]^{0{\cdot}414} \text{kg/h}$$

NOTE — *See* also **D-3.2** of IS : 8108 (Part 1)-1984*.

B-5. OUTPUT RATE

$$\text{Corrected output rate, t/h} = E_c \times \frac{79}{21 - g_c} \times \frac{1}{1\,000}$$

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*Test code for grain dryers: Part 1 Selection and preparation for test (*first revision*).

†When run mean exhaust relative humidity is between 70 percent and 80 percent, corrections should be made using the procedures of both Method A and Method B, and the average of the two corrected results inserted in Table 1.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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